**Problems that want to be solved:**

Various studies have been implemented in the literature to achieve a superior design using multi-channel EEG signals. This paper proposed a novel framework for the automatic P300 detection-based BCI model using a single EEG electrode.

Solution:

introduced a denoising approach using the bandpass flter technique followed by the transformation of scalogram images using continuous wavelet transform. The derived images were trained and validated using a deep neural network based on the transfer learning approach.

Data Set:

-The dataset consists of nine subjects; fve are disabled, and the remaining four are healthy subjects

-The images are displayed in arbitrary orders. Each image lasted for 0.1 s followed by 0.3 s of the gap, i.e., the interstimulus intervals (ISI) were 0.4 s. The sampling rate of the EEG signal was 2.048 kHz recorded from 34 electrodes

-this study employed a single channel i.e., Pz electrode (13th channel in the database) for our analysis. The raw EEG signals are afected by biological noises like eye movements, muscular movements, electrodermal response

Flashing Details:

The data of each subject is composed of four sessions. Each of the sessions consisted of six runs; they corresponded to six images which had displayed in a six‑cell paradigm. The images were flashed in random order. Each flash of an image lasted for 100 MS and then during 300 MS none of them were flashed. In a six‑cell paradigm

Preprocessing:

1. biological noises consist of low-frequency ranges (below 12 Hz), we employed 6th order forward-backward Butterworth bandpass filter with a cutoff frequency of 1 Hz and 12 Hz for the removal of biological noises
2. normalizing the signal through this equation:

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1. we transformed the normalized EEG signal into scalogram images using the CWT method
2. The CWT transformed a 1-D EEG signal into a single image (2-D) that holds time-frequency and amplitude using a filter bank approach. The filter bank is the predefined parameters to be performed on the input data applied. In this paper, we set the default filter bank parameters. We applied Morse for this experiment as it provides excellent time-frequency localization for EEG signals
3. used a pre-trained CNN model that required 2-D data as an input; hence, it needed a transformation of 1-D EEG signal into compatible data (2-D) for the trained network
4. The scalogram images consist of unique characteristics like amplitude, time, and scale. Hence, this amplitude-time at varying scales is used as a feature for analyzing the BCI model. The generated scalogram images are rescaled and normalized before training the model according to the input specification
5. the input scalogram images were resized to 224×224 pixels before training the model.

Modeling Algorithm:

3-layers, such as convolution layers, pooling layers, and fully connected layers. CNN model is mainly used to analyze the image signal

- A pre-trained AlexNet model based on a transfer learning approach to predict the classification performance of the BCI model. The final layer (Fully connected layer/output layer) of the training model has been modified to make the network compatible with the input EEG sample and classes. We have trained the model using two different learning rates (1e−3 and 1e−4) to estimate the classification performance. Training/learning consist of 80% of trial data (target and non-target trials) and validating/testing consists of the remaining 20% of trial data (target and non-target)

- distributed the training data into 11 epochs comprised of 250 iterations. Minibatch size parameter defines the value that characterized the no. of samples. The value for minibatch size is set to 10

Accuracy:

* average classification accuracy for disabled subjects lies in range from 92.69 to 96.32%
* the average classification accuracy for healthy subjects lies between 93.5 to 100%

Extra Informations:

* the time-frequency features after denoising the EEG signals enhance the classification performance in terms of bitrate and accuracy of the BCI model.
* relation between the P300 detection and its effects on the image identification paradigm concerning the number of epochs